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MANAGEMENT OF AGRO-WASTE BY USING AS AN ADDITIVE TO CONCRETE AND ITS ROLE IN REDUCING COST PRODUCTION: IMPACT OF COMPRESSIVE STRENGTH AS A CASE STUDY

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Abstract- Solid waste from household, industrial and food consumption uses is a very important part of municipal waste. If this waste is used appropriately, a great effort and a lot of money will be saved. In addition to the benefit that will accrue to the environment from reducing and exploiting waste. One of these types of residues is the agricultural wastes, such as various peels, husks, rinds and shells, including sunflower hulls. The current research deals with the study of adding hulls of sunflower grains in different weight ratio to the concrete mixture with proportions (4:2:1) (gravel: sand: cement) and 0.45 water: cement ratio. The compression strength of concrete cubes was measured due to this addition. Concrete was prepared according to the reference concrete mixture and admixtures adding sunflower hulls to the concrete. The obtained results showed that the compressive strength of the concrete mixture gradually increased with the increasing the percentage of sunflower hulls added to it. The increase continues until it reaches its maximum value at a certain weight ratio, and then declining sharply until the models fail completely. By these results, a new manner for managing the municipal wastes and proposes a cushy, unpretentious, advantageous, economical and eco-friendly method was introduced. Moreover, the idea of this paper highlights suitable way to dispose of many types of junk simultaneously, achieving the zero residues level (ZRL) concept.

Keywords: Compressive Strength Materials, Additives Materials, Peels, Agro-Waste and ZRL.

1. INTRODUCTION

The previous civilizations developed cement into what looks like the types actually used [1]. The employing of cement was so powerful that some of their structures and embankments, like the Pantheon Dome in Rome and the city of Caesarea in Palestine, are still standing today [2]. The Romans blended hydrated lime (lime added to water) with pozzolana (volcanic ash) for the cement industry [3]. People missed the technique of cement manufacture since 5th century AD when the Roman Empire is fall [4]. The Romans invented water cement, which solidifies with water. John Smeaton, a British engineer in 1756, was capable to reintroduce water cement by combining hydraulic lime and Italian pozzolanic ash mud [5]. In the 19th century, massive engineering undertakings necessitated the production of fine water cement [6]. Water cement was first manufactured in 1806 by James Perry from nodular limestone lumps of London clay, and this type of cement became known as Latin cement [7].

James Cold received a patent for water cement made from a limestone and clay mixture in 1815, and John Aspdin enhanced the process by temperature increases [8]. By blending, crushing, calcination, or re-crushing known amounts of limestone and clay, Johannes was able to synthesis high-quality cement resembled to traditional cement [9]. Johnston produced the first approved cement in 1855 [10]. Around 1879, the continuous kiln was invented, preceded by the first rotary kiln, which is still globally used [11]. In 1825, the structure of Erie Canal formed the beginning massive demand for cement in the United States of America. The American engineer (Canvas White) discovered a rock in Madison County, New York, USA. The natural hydraulic cement can be manufactured from it after a little treatment. The cement made of this rock was used to construct the canal [12].

Around 1879, the continuous kiln was invented, preceded by the first rotary kiln, which is still used. One famous example of this is the South Bank Building Complex in London [11]. Also, reinforced concrete was also used extensively in giant installations to extract petroleum from the depths of the sea. Because the concrete's resistance to seawater is much better than that of steel or other minerals that erode when exposed to seawater [10]. In British waters, concrete in base structures gradually declined in front of steel. From the other hand the Norwegians were sticking to their use due to the safety factors present in the concrete [13].

Multiple attempts were made to obtain improved and less expensive concrete mixtures, which were evident in the precast concrete glass panels. But only a few of these attempts reached the required level [14]. Concrete can be defined in concept as a complex mixture of (coarse and fine aggregate), cement, and water with some voids (pores).

Other materials are also used for achieving specific qualities. These substances amount in the concrete mixture are determined based on the type of work to be done and the supplies available [13]. The concrete result from putting these elements together gradually solidifies over time until it is solid and strong. Its specifications vary depending on the fundamental components as well as the casting process and treatment quality [10]. Water is required for the chemical interaction between cement and water, as well as for the absorption of water by other substances in the concrete. The water contributes ductility to the fine, coarse aggregate and cement combination, making it easier to work with and mold [3]. Other additives are substances or mixes of components that are added into concrete to enhance one or more aspects of the mixture while it is fresh, frozen, or treated [15]. Many additives impact more than one attribute of concrete, and they are typically grouped according to their primary purpose of application [14].

It can sometimes alter the desirable qualities of concrete in the opposite direction, i.e., it might increase one feature while having a detrimental effect on another [16]. The additives specific effects are determined by variety of factors, including the additive's type, quantity, chemical characteristics, or cement content in the mixture. Moreover, the additives type, chemical characteristics, gypsum content in the mixture, the time of adding the additive to the mixture, and other variables [15]. The labor of the additive and its influences are commonly explained by the maker and provider. But the specifics of his attitude in the mixture (especially formerly unutilized additives) must be tested initially, before conducting them in concrete works by manufacturing empirical mixtures or performing labor [12]. A lot of researches have been done to see how different additives improve the concrete mixture. The Pomegranate peels and rice husks are two of the materials utilized [12,14]. Rice husks, a waste product of rice production, have many beneficial uses before using as an admixture to concrete [14]. One of the famous uses was employed it as a raw material for water purification from heavy metals [17, 18, 19, 20]. Moreover, it was used to treat polluted aqueous solution by organic acids [21], eutrophication [22], and radioactive elements [23].

Also, the rice husks proved suitable ability to remediate hardness from wastewater [24]. Rice husks when mixed with concrete improve the properties of the concrete. Also, provides a number of important benefits, because the rice husks contain high amount of silica in its composition. However, they pose a threat to the environment due to damage caused in the area where they are disposed of [12]. One of the numerous benefits of concrete using rice husks is its capacity to withstand high pressure. This may be due to a pozzolanic material of higher-pressure strength than standard Portland cement [25]. It also has excellent water resistance properties (not permeability) and reduces water penetration by up to 60% [3]. It has an excellent resistance to chlorine that erode the reinforcing steel, as well as lowering water temperature and preventing fractures during casting [26]. This research examines the possibility of using sunflower hulls residues as an additive in different ratios for the concrete mixture of (4:2:1). The behavior of the mixture can be concluded from the compression strength of the concrete cubes prepared. Also, from the density of fresh and dry concrete mixture.

2. THE EXPERIMENTAL PROCEDURES

2.1. Motor Modeling

Cement: "Ordinary Portland cement" (OPC) was utilized, which was made from Tasluja-Iraqi origin Bazian and met "Iraqi Standard (No. 5 of 1984) [27]". The physical and chemical testing results of the cement utilised in this study are illustrated in Tables 1 and 2.

Table 1. Chemical test results

Chemical Description	Tested Cement %	Specification Limits %
CaO	62.42	60 – 69
SiO_2	21.30	18 – 24
Al_2O_3	5.52	4 – 8
Fe_2O_3	4.25	2 – 4
MgO	2.53	2 – 5
K_2O	0.72	
Na_2O	0.53	
SO_3	0.83	0.3 – 2.7
CaO	1.36	0 – 2
Insoluble Residue	0.54	
Loss on Ignition	0.5	0.1 – 0.5
Factor of Lime Saturation	0.8935	0.66 – 1.02
C_3S	49.00	45 – 65
C_2S	23.88	10 – 25
C_3A	7.57	7 – 12
C_4AF	13.00	11 – 15

- Sand: The sand used is according to the Iraqi specifications 45, 1984 [27], as shown in Table 3.
- Gravel: The gravel used is according to the Iraqi specifications 45, 1984 [27], as shown in Table 4.
- Water: The water to cement ratio was 0.45 for all mixes.
- Sunflower hulls: Sunflower hulls which are left over from domestic consumption were used.

Table 2. Physical test results

Physical Description	Tested Cement %	Specification Limits
Particular gravity	3.09	---
Consistency in Practice	29	26-33
Fineness	3350	> 2300
Soundness	0.3	< 0.8
Time of Initial Setting	122	> 60 min
Time of Final Setting	360	< 600 min
Compressive strength (3 days)	17.6	> 15 $N.mm^{-2}$
Compressive strength (7 days)	25.3	> 23 $N.mm^{-2}$
Flexural Strength (3 days)	8.25	---
Flexural Strength (7 days)	12	---

The result was retrieved from a precise sieve and collected in moisture-proof bags until usage, where it was dried by the heat of the sun for one week in the summer. These dried and powdered crusts were employed without any extra treatment to produce concrete mixture models.

Table 3. Sand sieve analysis

Sieve size mm	Passing (W %)	Iraqi specification limit, zone 2 [19]
10	100	100
4.75	94	90-100
2.36	84	75-100
1.18	78	55-90
0.6	56	35-59
0.3	27	8-30
0.15	3	0-10

Table 4. Gravel sieve analysis

Sieve size mm	Passing (W %)	Iraqi specification limit, zone 2 [19]
37.5	100	100
20	99	95-100
10	42	30-60
5	2	0-10

2.2. Concrete Mix

Two types of concrete mixes were prepared in this investigation. The first is a reference mixture of (4:2:1) (gravel: sand: cement) ratio and water: cement is 0.45. The other type is a concrete mixture with the same previous compositions in addition to a number of sunflower hulls (weight ratio). The added ratio ranged between 0.5-3 %. The details of concrete mixtures used in the study are shown in Table 5.

Table 5. Concrete mix for this study

Cement $Kg.m^{-3}$	Sand $Kg.m^{-3}$	Gravel $Kg.m^{-3}$	(Water: cement) ratio
300	600	1200	0.45

The fine and rough aggregates were firstly water washing to remove any dust, ash or other contaminants. Then dry naturally by ambient air overnight in a clean location. The sand, cement sunflower hulls and water was mixed together using local electrical mixer of 25 kg capacity. Steel cubic molds of (0.15×0.15×0.15) m dimensions were utilized to pour concrete mixture on three levels according to BS: 1881: part 113: 1983 [28] is used for testing the compressive strength. Furthermore, a cylindrical model with a height to diameter ratio of (2:1) is used to determine the density test.

To achieve homogenous concrete mixture, a mechanically piled was used supported by the vibrating apparatus for 10-15 seconds. After casting, the concrete models were nylon wrapped overnight, and then the models were taken away from the molds. Then, the various models are put in special equipped tanks full of 20-25 °C tap water for curing and remaining in the curing tanks until testing time. The next step was put the samples under a conventional compressive strength machine at a specified speed until it cracked, which generally took 180 seconds. The compression strength test was performed in this investigation in accordance with the BS 1881: part 116 [29] for concrete cubes prepared at the age of 7 days and 28 days. The test was performed using a universal machine (Wekob) with of 2500 kN capacity and 15 MN/m^2/minutes described speed until models crack. Three cubes were checked for the reference concrete mixture and addition mixtures at each age to calculate compression strength. The approved compression resistance was calculated as the resistance rate for three concrete cubes.

3. RESULTS

3.1. Density of Fresh Concrete

The density of fresh concrete was decided in accordance with ASTM C-138, where a bowl made of stainless steel is taken [30]. The size is detected by the size of the rough aggregate used in preparing the concrete mixture. The weight is recorded which is empty and then filled with water and records the weight and subtract the previous two weight. The volume of the container is known from the knowledge of the weight of the water, which represents the exact volume of the container. The container shall be filled with soft concrete prepared in advance. The period between the completion of preparation and the test procedure should not exceed 5 minutes. Then, the concrete will be compacted using an internal vibrator, and the shaking should be at the lowest possible time to achieve adequate stacking of the concrete (in stages of, 3 seconds shake and 3 seconds pause).

The shaking will continue until the concrete surface is smooth and glazed because excessive shaking may cause granular separation. After that the surface of the concrete is leveled precisely by the construction trowel. The iron vessel is cleaned from any concrete residue on it and the clean container weight and recorded with the concrete it contains. By subtracting the weight of the bowl from the previous weight, it can get the weight of the concrete alone. Then from dividing this weight by the size of the bowl previously extracted, the density of the soft concrete is known. In this research an 11-liter iron container was chosen to perform the test. The results are shown in Table 6 and Figure 1.

3.2. Density of Dry Concrete

The density of dry concrete was decided in accordance with the ASTM C-567 [31]. The concrete cylinder was placed after casting and ripening with a lifespan of at least 24 hours. No more than 32 hours in a heat furnace of 110±5 °C, for a period of 72 hours or pending access to a steady weight. The cylinder is cooled to room temperature, recording its weight and size, and finding its density. The results are illustrated in Table 6 and Figure 1. From the above observations, it’s clear that the density of the fresh and dry concrete increases with increasing the percentage of sunflower hulls added. This can be explained by the fact that the hulls of the sunflower have been added (not exceed to 0.7%) in the form of very fine grains to the concrete mixture. It exemplifies an amount added to the concrete weight, which denotes an increase in the density of the volume stability.

So, the density of concrete will increase with both fresh and dry types are the result of adding hulls. The increasing of the hulls added amount, the higher substance of the lead element loaded on it. The more added weight will be made, the denser the concrete. The current result is consistent with the findings of [14, 16].

Table 6. Study results of fresh and dry density of concrete mixes

Samples tested	Sunflower hulls		Concrete density ($g.cm^{-3}$)	
	Hulls amount (gram)	Hulls ratio (%)	Fresh	Dry
1	Reference	0	2.205	2.105
2	0.1	7.090	2.268	2.124
3	0.2	14.180	2.269	2.153
4	0.3	21.270	2.288	2.165
5	0.4	28.360	2.309	2.173
6	0.5	35.450	2.316	2.180
7	0.6	42.450	2.332	2.189

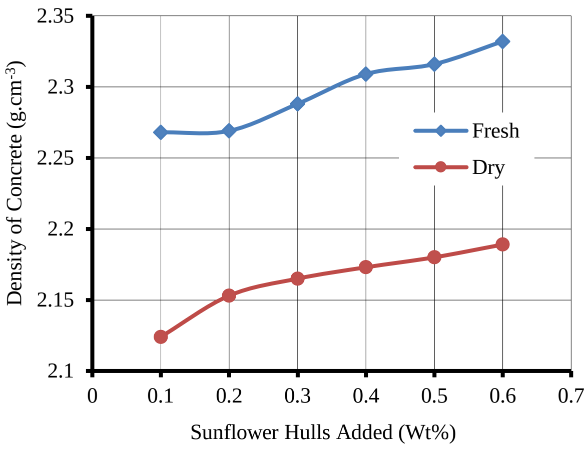

Figure 1. The effect of adding sunflower hulls to the density of fresh and dry concrete

3.3. Compressive Strength

The compression strength examination finding of the basic concrete mixture (reference) and the addition blending ratios of sunflower hulls are elucidated in Table 7 and Figure 2. In general, adding any type of fine grain, including hulls of crushed sunflower (alone) to the concrete in a limited percentage, increases compressive strength in a very simple way. This result may be attributed to incorporate them requires as an adding of water to the combination, which reduces the compression strength. However, the results obtained in this study indicate the opposite. The compression strength of the concrete cubes decreases with decreasing the % sunflower hulls added to the concrete at the age of 7 days and 28 days, compared to the reference concrete cubes up to 0.15%. After which the strength begins decrease until the models fail completely at 0.7%.

The reason for this may be due to the fact that sunflower hulls granules may have interfered with grains of aggregates. The aggregates are rougher than them several times, resulting in reduced the concrete voids. This may lead to strength the nature of the interlayer, commonly full of voids. It leads to the undermining of concrete, and therefore the utilizing of hulls of sunflower will lead to filling. As a consequence, eliminate these gaps; enhance the region's homogeneity, and therefore its strength. Furthermore, the compression strength increasing of the concrete resulting from the addition of the sunflower hulls due to the increased adhesion strength between the grains of fine hulls and concrete cement. Another reason may be due to dependent on some physical and chemical properties resulting from the mineral composition of the shells. It is possible that the chemical composition of the sunflower hulls is close to a certain limit with the chemical composition of cement. The result is consistent with [16].

Table 7. Compressive strength results of this study for reference and sunflower peel concrete samples

Number of concrete mixes	Sunflower hulls		Compressive strength ($N.mm^{-2}$)	
	Hulls ratio %	Hulls amount*	7 Days	28 Days
1	Reference	0	21.68	25.77
2	0.001	0.709	23.81	27.72
3	0.05	3.545	26.00	30.25
4	0.10	7.090	27.15	31.50
5	0.15	10.635	27.50	31.88
6	0.20	14.180	27.00	31.40
7	0.25	17.275	25.90	30.15
8	0.30	21.270	24.15	28.20
9	0.35	24.815	22.00	25.53
10	0.40	28.360	19.35	22.70
11	0.45	31.905	16.55	19.35
12	0.50	35.450	13.15	15.70
13	0.55	38.995	10.00	11.76
14	0.60	42.450	6.64	7.73
15	0.65	46.085	3.11	3.61
16	0.70	49.630	-	-

* The amount of sunflower peel (gram) added to one sample dimensions (0.15×0.15×0.15) m

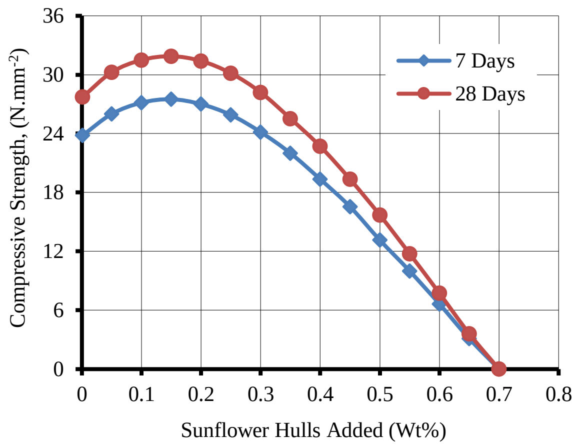

Figure 2. The effect of adding sunflower hulls on the compressive strength

4. CONCLUSION

The results obtained show that the solid wastes have many fields that can be benefited from. One of these fields can be used as an admixture for concrete mix within specific ratios to enhance their operational properties and increase their characteristics. Adding sunflower hulls to the concrete had a great role in increasing the compressive strength as well as in enhancing the density of the fresh and dry concrete.

The compression strength and density of both types is directly proportional to the increase of sunflower hulls ratio addition within certain limits and proportions. After which the strength begins to decrease gradually until the models fail. The results also showed that the best percentage of sunflower hulls added was 0.15%. Thus, this study demonstrates a new idea for the exploitation of agricultural wastes. In the same time, concentrate the concern to significant part of Municipal Solid Waste (MSW), accessing to ZRL concept.

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